

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

### **AMMTO & IEDO JOINT PEER REVIEW**

May 16<sup>th</sup>-18<sup>th</sup>, 2023

Washington, D.C.

# DIGITAL FACTORY PROJECT | AMMTO

Vincent Paquit & Oak Ridge National Laboratory

36644 October 1<sup>st</sup>, 2019 to Present

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# **Project Overview**

 Goal: establish the Advanced Materials and Manufacturing Technologies Office (AMMTO) Manufacturing Demonstration Facility (MDF) as a national testbed for data science research toward the development of advanced manufacturing (AM) technologies, and to strengthen the US manufacturing ecosystem through industry collaboration and technology transfer



#### Targets

- Industry 4.0: accelerate digital transformation of US manufacturing
- Certification and qualification of AM components for critical applications
- Digital manufacturing workforce development & augmented intelligence

#### Alignment with AMMTO Mission

- Define specifications of a deployable cyberphysical infrastructure
- Optimize and allow shorter supply chain
- Host a national AM database for scientific R&D
- Create framework for data informed qualification
- Improve energy efficiency in fabrication & application

# **Project Outline**

**Innovation:** Ensemble of data driven solutions to support (1) the deployment of smart manufacturing technologies, and (2) the development of new standards for certification and qualification of AM **Project Lead:** Vincent Paquit

Project Partners: DOE labs, DOD facilities, Industry licensees

**Timeline:** October 1<sup>st</sup>, 2019 to Present

Budget:	FY21 Costs	FY22 Costs	FY23 Costs	Total Planned Funding
DOE Funded	\$3.0M	\$3.0M	\$3.0M	\$30M
Project Cost Share	N/A	N/A	N/A	N/A

#### End Project Goal:

- Create a secure and nationally accessible manufacturing database and digital platform allowing manufacturers to retrieve digital twins of components produced by advanced manufacturing technologies commonly used by SMEs
- Establish a nationwide digital manufacturing strategy for advanced manufacturing certification and qualification

#### **Current Users Base** DENSO DEVCOM (ge) **GE** Additive Sandia Lawrence National (cetim Livermore Laboratories National Laboratorv MORF3D NAVAL NUCLEAR LABORATORY ZEINN Georgia LOS Alamos U.S. AIR FORCE Beehive3 MINES. SIGMA Solar Turbines USCAR A Caterpillar Company Pacific Northwest BOEING SIEMENS **Raytheon** Technologies SIEMENS Argonne framatome

## **Background & Strategic Approach**

• Industry 4.0: accelerate digital transformation of US manufacturing



• DOE national labs network to support manufacturing R&D

manufacturing

# **Background & Strategic Approach**

• Certification and qualification of AM components for critical applications



 Variability in fatigue performance for additively manufactured components is much higher than for conventionally manufactured components



- Conventional approach
  - Not adapted to AM flexibility and potential
  - Expensive
  - Suboptimal
  - Not transferable to new component / material

Manufacturing science database of process-property relationships

6

perties Predictic

Born qualified component design

-Mechanical Btn -Fatigue -Toughnessa -High Temperati

**CAK RIDGE** 

What is needed?

 Integrated in-Situ Sensing Technolog
Repositability and reliability
Next Generation Systems

- Gain extensive knowledge of the manufacturing process from data
- The manufacturing objective becomes the driver of the manufacturing process

# **Background & Strategic Approach**



### **Results and Achievements**



#### Sensing, Measurement & Visualization



### **Results and Achievements**

#### Data Analytics & Al

#### Peregrine





#### Modeling, Simulation & Process Control



#### **Closed-Loop Melt Pool Size Control**



Melt pool monitoring





Control response



### **Results and Achievements**

#### Peregrine



- >30 Commercial copyright license
- 2022 FLC Excellence in Technology Transfer Award
- Deployable on edge/embedded devices
- Co-development with other DOE labs
- No commercial alternative

### Digital Discipline



- DOE NE AMMT program leverages AMMTO digital platform
- Digital twin architecture considered by other entities
- Release open datasets



Layer-wise Imaging Dataset from Powder Bed Additive Manufacturing Processes for Machine Learning Applications (Peregrine v2022-10.1)

### Industry Impact #1



- Solar Turbines
- In-situ monitoring for process development and quality control
- Fabricate 200+ near netshaped Mercury 50 Stage 2 airfoil (high gamma prime Ni-base superalloy)
- Successfully tested (stress and hot fire)

#### Industry Impact #2



#### Transformational Challenge Reactor

- Program leveraged the digital platform for process development and quality control
- Fuel cell brackets in commercial nuclear reactor

# Future Work, Technology Transfer, & Impact

Peregrine

#### **Future Work:**

MDF Digital Test Bed

Manufacturing Science Database

#### Certification and Qualification Framework

### **Technology Transfer:**

• Software and Hardware: use a combination of open and commercial licensing

### Impact:

 AMMT Program: five national labs collaborating to establish a unified software architecture to accelerate the certification of nuclear component







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